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SEASAT-A ASVT
COMMERCIAL DEMONSTRATION
EXPERIMENTS

RESULTS ANALYSIS METHODOLOGY
FOR THE SEASAT-A CASE STUDIES

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NOTE OF TRANSMITTAL

This report is intended to provide a convenient reference to the case studies that will be performed by commercial and industrial users using the data gathered by SEASAT-A during its operational life. The purpose of these case studies is to evaluate the impacts of the SEASAT-A data on the business operations of a selected set of commercial and industrial users. The report documents the current understanding of the objectives and data requirements of the case studies, and the methodology to be used to estimate the economic benefits of improved ocean condition and weather forecasts.

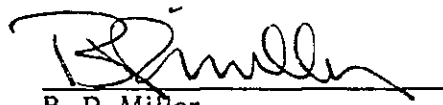

B. P. Miller
Vice President

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1. INTRODUCTION

The SEASAT-A Commercial Demonstration Program ASVT consists of two sets of experiments. One set of experiments involves the evaluation of a real-time data distribution system, the SEASAT-A User Data Distribution System (UDDS), that provides the capability for near real-time dissemination of ocean condition and weather data products from the U.S. Navy Fleet Numerical Weather Central to a selected set of commercial and industrial users. The second set of experiments consists of case studies, performed by commercial and industrial users, using the data gathered by SEASAT-A during its operational life. In these case studies it is intended that the commercial and industrial users evaluate the impacts of the SEASAT-A data on their business operations.

This document describes the approach to be followed in the performance of the case studies, and the methodology to be used in the analysis and integration of the case study results to estimate the actual and potential economic benefits of improved ocean condition and weather forecast data.

2. BACKGROUND

2.1 The SEASAT Project

The SEASAT Project was a proof-of-concept mission whose objectives included demonstration of techniques for global monitoring of oceanographic and surface meteorologic phenomena and features, provision of oceanographic data for both application and scientific areas, and the determination of key features of an operational ocean dynamics monitoring system.

SEASAT-A, a 40-foot, 5050-pound ocean-monitoring satellite, was launched from Vandenberg Air Force Base, California, into a near-polar circular orbit 800 km (500 miles) above Earth at 6:12 p.m., PDT, on Monday, June 26, 1978. During its period of operation, SEASAT-A circled the Earth 14 times daily, covering 95 percent of the global ocean area every 36 hours, and completing 1503 revolutions of the Earth.

The SEASAT-A sensor complement comprised a radar altimeter (ALT), a Synthetic Aperture Radar (SAR), a SEASAT-A Scatterometer System (SASS), a Scanning Multichannel Microwave Radiometer (SMMR), and a Visual and Infrared Radiometer (VIRR). All of these sensors, except the SAR, operated continuously; telemetry from them, as well as from all engineering subsystems, was sent in real time when over a ground station and recorded on a tape recorder for later transmission to provide data for a full orbit. SAR data had to be transmitted in real time, without the use of the onboard recorder, to specially equipped stations because of its high data rate. The normal duty cycle for the SAR was 4 percent.

The five sensors were integrated into a sensor module that provided mounting, thermal control, power conditioning, telemetry and command support to the instruments. The second major element of the spacecraft was an Agena bus which

provided attitude control, electrical power, telemetry and command functions to the sensor module. In addition to these on-orbit functions, the Agena bus also provided injection stage propulsion and guidance to orbit. The spacecraft was 3-axis stabilized with all sensors earth pointing and is shown in its on-orbit configuration in Figure 1. To provide near global coverage, the spacecraft was injected into a 790 km, near-circular orbit with an inclination of 108 degrees and a period of approximately 101 minutes. Design lifetime was one year on orbit, with expendables provided for a three-year life.

On Monday, October 9, 1978, a catastrophic failure occurred in the satellite power subsystem causing a loss of radio signals soon after it passed over an Australian tracking station shortly before midnight.

On Tuesday, November 21, SEASAT-A was officially declared lost. The satellite operated from June 26 to October 9, a period of 106 days. The sensors were turned on for data collection on the 10th day after launch. The SAR, SASS and the SMMR operated as planned thereafter, while the ALT was shut off for two nine-day periods because of satellite thermal control and power problems, and the VIRR failed some sixty-two days following launch. All of these instruments, however, returned large quantities of global data of excellent quality. During the 106 days between launch and failure, SEASAT-A relayed a massive amount of information on surface winds and temperatures, currents, wave heights, ice conditions, ocean topography and coastal storm activities.

2.2 Commercial Demonstration Program

The Commercial Demonstration Program was planned as a pilot program with industrial community participation in a series of experiments to utilize the data derived from the SEASAT-A mission. The objectives of the Commercial Demonstration Program were to:

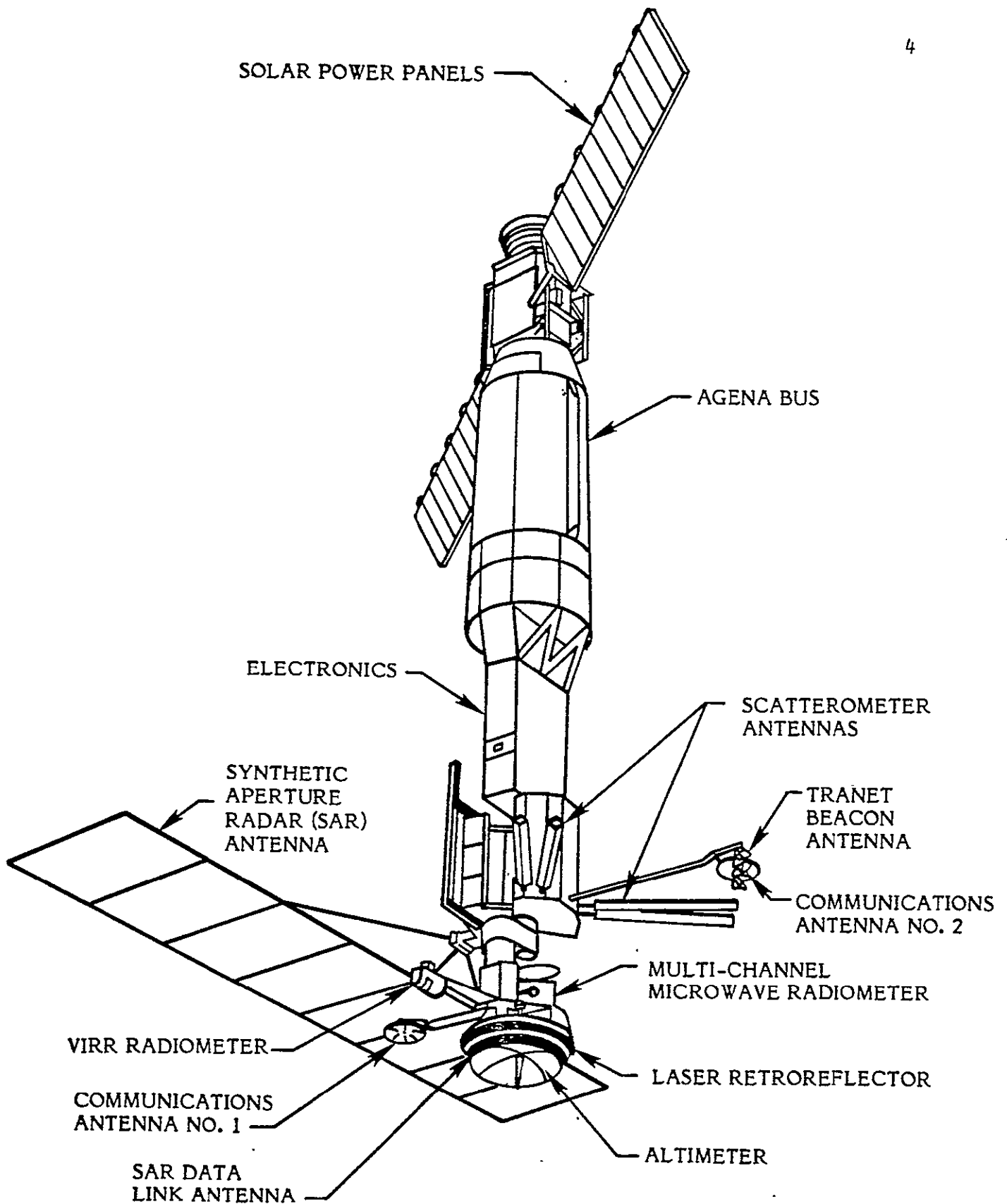


FIGURE 1 THE SEASAT-A SPACECRAFT

- Identify those features of a SEASAT system found to be important to commercial and industrial users
- Evaluate the importance of SEASAT-A data to those users
- Develop and broaden the technology transfer process, and
- Obtain an experimental data base on which to refine estimates of the economic benefits from an operational SEASAT program.

It was planned that participants in the program would receive SEASAT data products and other ocean weather condition information in near real time from the U.S. Navy Fleet Numerical Weather Central (FNWC) in Monterey, California.

Industry participation in the program was to be based on NASA's assessment of the potential contribution to the program of each proposed industry experiment. A ground rule of the program was that participants were to bear the expense of their own experimental program, excluding costs of data products generation and transmission to their individual terminals. Access to the data at FNWC was to be provided by means of "dial-up" interface equipment. No federal government funds were to be transferred to the commercial program participants.

The experimental use of SEASAT data products by commercial participants was to take place during a period of approximately two years, following which each participant was to evaluate the results in the context of its own business operations and provide NASA with a detailed report. The experimental period was expected to commence in late 1978 or early 1979.

In November 1977, a workshop involving the commercial and industrial experimenters was held at Princeton University. The purpose of this workshop was to begin the process of definition and development of the experiment program. In this workshop, a preliminary definition of the experiment concept and data requirements was obtained for 22 candidate commercial demonstration experiments [1].

Beginning early in 1978, a series of meetings were held with each commercial experiment team to assist each experimenter in preparation of his Experiment Plan, to define the experiment data requirements and to obtain agreement on the text of a Cooperative Agreement between the experiment team and NASA. This effort resulted in a User Requirements Document which was published in September 1978. The User Requirements Document defined the data product and data distribution needs for each of the 22 commercial experiments [2].

By the time of the failure of SEASAT-A during early October 1978, the special purpose computer equipment to enable the commercial experimenters to "dial-up" SEASAT and FNWC data products via a User Data Distribution System (UDDS) had been installed at FNWC and the development of the software for this system was proceeding. Experiment Plans had been completed for all of the planned commercial experiments. Terminal equipment had been leased by NASA for use by certain experimenters and a telecommunications network had been established to provide the experimenters with access to the data at FNWC. It was anticipated that the system to access SEASAT and FNWC data products and distribute them to the commercial experimenters would be fully operational by February 1979.

2.3 The Case Studies

In early November 1978, following the failure of SEASAT-A, a meeting of the commercial experimenters was convened at JPL. The purpose of this meeting was to convey the current status of the SEASAT-A satellite and the Commercial Demonstration Program to the experimenters in order to evaluate the interest of the commercial experiment teams in the possibility of proceeding with a modified experiment program. In this meeting, NASA described the data and facilities available to the commercial experimenters, and the experimenters in turn advised

NASA on their interests and decisions relative to the possibility of performing a modified experiment program[3].

The general conclusion of the commercial and industry personnel present at this meeting was that although the SEASAT-A satellite had failed, the objectives of the Commercial Demonstration Program could (and should) be fulfilled. The participants at the meeting made a strong case that the maritime and offshore industries had made a commitment to the SEASAT-A program concept and that they wanted to continue to be partners with NASA in an oceans program. Two broad areas of continuation for the Commercial Demonstration Program were outlined, as follows:

- Evaluation of the Real-Time User Data Distribution System (UDDS)

Commercial and industrial consumers of ocean conditions and weather data do not at the present time have access to this data on a real time or demand basis. The SEASAT-A UDDS is intended to provide a computer-controlled network for near real-time distribution of data from FNWC to the commercial users. As a result of the failure of SEASAT-A, the SEASAT content is removed from the FNWC data. Since the concept embodied in the UDDS is likely to be an important part of any future operational ocean information system, it was considered important to complete the evaluation of the UDDS as a real-time data distribution system as a free-standing system element.

- Case Studies

The 96 days of data gathered by SEASAT-A prior to failure can be analyzed in a set of nonreal-time case studies in an effort to gain insights into the possible economic and operational impacts of SEASAT-type data on commercial ocean operations. These case studies will replace many of the planned real-time experiments. The design of each case study will be specific to a given geographical location and time (corresponding to the SEASAT-A data set), and will also be specific to a given operation such as offshore drilling, ship transit or fishing that may have been conducted by the study team during the time period covered by the SEASAT-A data set. In these case studies, it is planned that the experimenter will evaluate the impacts which SEASAT-A data could have produced for operations conducted by the user organization during the life of the satellite.

The purpose of this report is to describe the approach to be followed in the performance of the case studies, and the analysis and integration of the case study results.

3. GOALS AND CONSTRAINTS OF THE CASE STUDIES

The case studies are intended to replace certain of the real-time and nonreal-time experiments that were to be performed as a part of the SEASAT-A Commercial Demonstration Program. As a result of the SEASAT-A failure, the scope of the case studies is limited by the data collected during the useful lifetime of SEASAT-A. As described in Appendix A, global data with the ALT, SASS and SMMR was collected during the operation of SEASAT-A. Virtually complete coverage was obtained with the SAR for the North American continent, Alaska and adjacent waters, along with some critical areas adjacent to foreign SAR receiving stations. The principal limitation of this data is that it covers only the period of roughly July through early October 1978. Thus, the main constraint of the data set from the perspective of the case studies is the lack of multiseasonal, multiyear content. Moreover, in order to minimize the problems of extrapolation, it is desirable that the case studies be based upon the activities of the commercial case study team during the operational period of SEASAT-A. These limitations of the data effectively constrain the case studies to activities performed by the commercial case study team during the lifetime of SEASAT-A.

Within the limitations of the available data set, the objectives of the case studies remain essentially the same as the objectives of the Commercial Demonstration Program described in Section 2.2. The goal of the case studies is to evaluate operational or economic impacts that SEASAT-A data could have produced through the analysis of specific weather and oceans condition sensitive operations conducted by the case study team during the life of the satellite[3].

4. THE CASE STUDIES

4.1 Beaufort Sea (ASVT No. 1)

4.1.1 Participating Organization(s)

1. Name: Gulf Oil Canada, Ltd.
 Address: 715 Fifth Avenue, S.W.
 Calgary, Alberta
 Canada T2P ON2
2. Name: Canadian Marine Drilling, Ltd. (CANMAR)
 Address: P. O. Box 200
 Calgary, Alberta
 Canada T2P 2H8
3. Name: ESSO Resources Canada, Ltd.
 Address: 339 50th Avenue, S.E.
 Calgary, Alberta
 Canada T2G 2B3

4.1.2 Case Study Manager

1. Name: B. Wright
 Address: Gulf Oil Canada, Ltd.
 715 Fifth Avenue, S.W.
 Calgary, Alberta
 Canada T2P ON2
 Telephone: (403)-268-4484
2. Name: B. Mercer/G. Davis
 Address: Canadian Marine Drilling, Ltd. (CANMAR)
 P.O. Box 200
 Calgary, Alberta
 Canada T2P 2H8
 Telephone: (403)-232-5550

3. Name: G. Spedding
- Address: ESSO Resources Canada, Ltd.
339 50th Avenue S.E.
Calgary, Alberta
Canada T2G 2B2
- Telephone: (403)-259-0335

4.1.3 Objective

The objective of this case study is to evaluate microwave data obtained from SEASAT-A as an aid to improving oil and gas exploration operations in the ice-infested waters of the Beaufort Sea. Figure 2 is an overview of the Beaufort Sea case study.

4.1.4 Data Needs

This case study involves SEASAT GDRs (primarily waves and winds) and SAR imagery. The primary emphasis in the case study is the SAR imagery.

4.1.5 Analysis

Three periods are selected for analysis between July and September to coincide with ice movements and with the collection of surface truth data. Surface truth data were collected from three drillships, artificial ice islands and aircraft. Analysis of the data will be undertaken jointly by all the participants. The participants further plan to conduct special workshops on data analysis and evaluation with other participants from ASVT Nos. 2 and 22.

4.1.6 Expected Output

Based on the results of comparison and analysis, assessment will be made of the utility of SEASAT-type data and their benefits to offshore oil and gas exploration in arctic operations and environment.

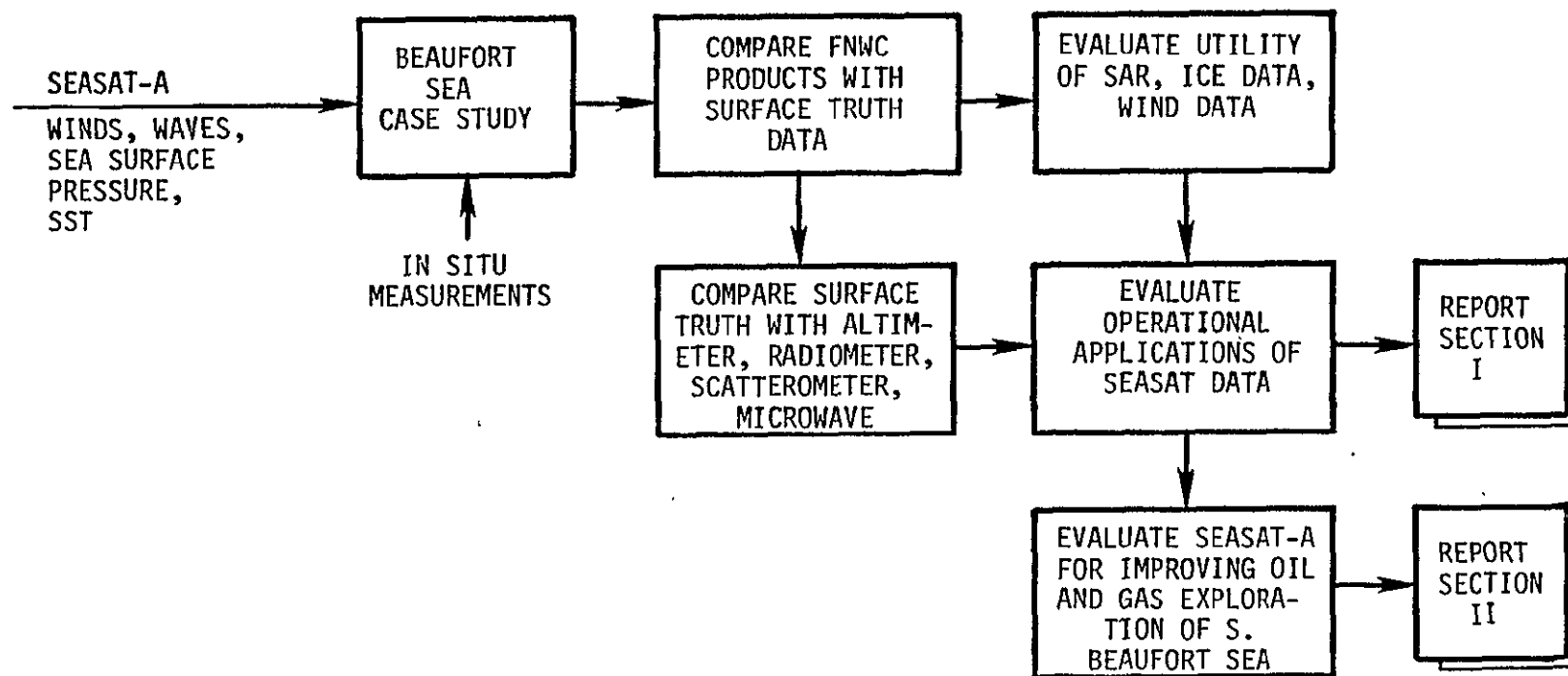


FIGURE 2 BEAUFORT SEA CASE STUDY

4.2 Labrador Sea Case Study (ASVT No. 2)

4.2.1 Participating Organization(s)

1. Name: ESSO Resources Canada, Ltd.
Address: 339 50th Avenue, S.E.
 Calgary, Alberta
 Canada T2G 2B2
2. Name: Total Eastcan Exploration, Ltd.
Address: Bow Valley Square 1/1600
 202 Sixth Avenue, S.W.
 Calgary, Alberta
 Canada T2P 2W6

4.2.2 Case Study Manager

1. Name: G. Spedding
Address: ESSO Resources Canada, Ltd.
 339 50th Avenue, S.E.
 Calgary, Alberta
 Canada T2G 2B2
Telephone: (403)-259-0335
2. Name: M. Jozan/D. Berenger
Address: Total Eastcan Exploration, Ltd.
 Bow Valley Square 1/1600
 202 Sixth Avenue, S.W.
 Calgary, Alberta
 Canada T2P 2W6
Telephone: (403)-264-9770

4.2.3 Objective

The objective of this case study is to verify SEASAT data with industry-collected surface truth data for oceanographic, meteorologic and sea ice monitoring and to assess the utility and benefits of SEASAT data to offshore drilling, design and production operations. Figure 3 is an overview of the Labrador Sea Case Study.

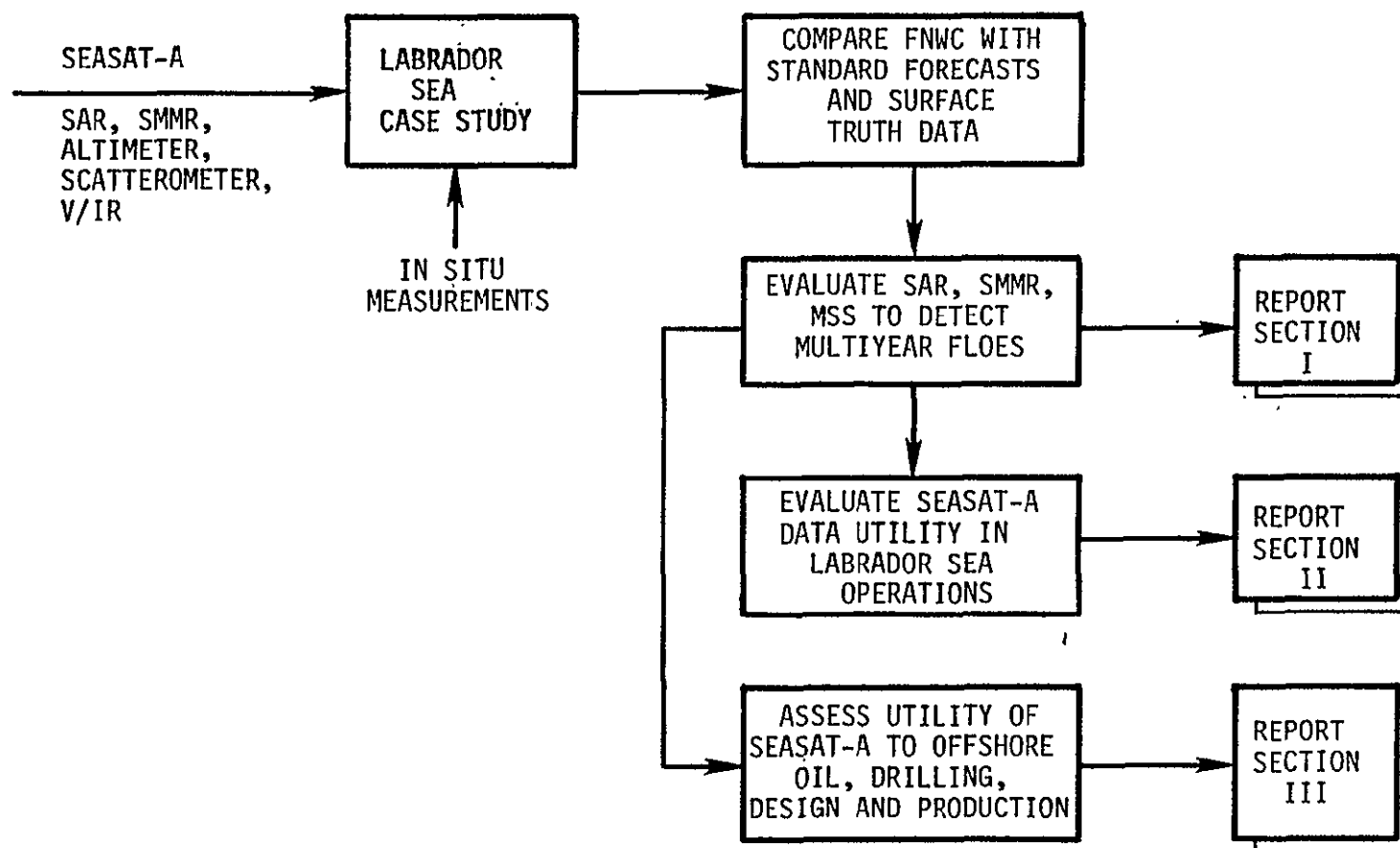


FIGURE 3 LABRADOR SEA CASE STUDY

4.2.4 Data Needs

Data requirements include SAR imagery and GDRs (waves and winds). Surface truth data were collected using a drillship, two oceanographic ship cruises, and aircraft; ice observations were made within 30 km of the drillship.

4.2.5 Analysis

These data will serve as the basis for comparison analysis and evaluation of SEASAT data and their utility in various stages of oil operations. The Atmospheric Environmental Services (AES) of Canada (ASVT No. 22) will cooperate in providing forecasts using SEASAT data for the Labrador Sea participants. Evaluation of such forecasts in comparison with past ones will probably be made during a planned workshop involving participants from all three ASVT's (Nos. 1, 2 and 22).

4.2.6 Expected Output

Based on the results of evaluations, assessment will be made of the utility and benefits from SEASAT-type data in future operational programs.

4.3 Gulf of Mexico Case Study (ASVT No. 3)

4.3.1 Participating Organization(s)

Name: American Gas Association

Address: c/o United Gas Pipe Line Company
2 Allen Center
P.O.Box 1478
Houston, TX 77001

4.3.2 Case Study Manager

Name: R.J. Simmons, Jr.

Address: American Gas Association
c/o United Gas Pipe Line Company
2 Allen Center
P.O. Box 1478
Houston, TX 77001

Telephone: (713)-237-4531

4.3.3 Objective

The objective of the Gulf of Mexico case study is to assess the utility of SEASAT-type data to improve design criteria for pipelines, correlate the effect of satellite data with subsurface conditions, and determine the accuracy of predicting severe storms. Figure 4 is an overview of the Gulf of Mexico Case Study.

4.3.4 Data Needs

Documented times of significant weather episodes in the Gulf of Mexico during the summer of 1978 are available for this experiment. During that time, Vega Weather Service, Inc. was under contract to provide one of the AGA member companies with forecasts and advisory services. Detailed records are available.

4.3.5 Analysis

SEASAT GDRs will be used to formulate forecasts on selected days where severe conditions existed in the Gulf of Mexico. These forecasts will then be compared with existing records for that time. In addition, surface truth data were collected from various platform operators. These data points will be used to validate sensor data accuracy and quality.

4.3.6 Expected Output

Based on the results of comparison, evaluation will be made as to data utility and potential benefits that could be obtained from a future operational satellite system.

4.4 U.S. East Coast Case Study (ASVT No. 4)

4.4.1 Participating Organization(s)

<u>Name:</u>	CONOCO
<u>Address:</u>	P.O. Box 2197 Houston, TX 77001

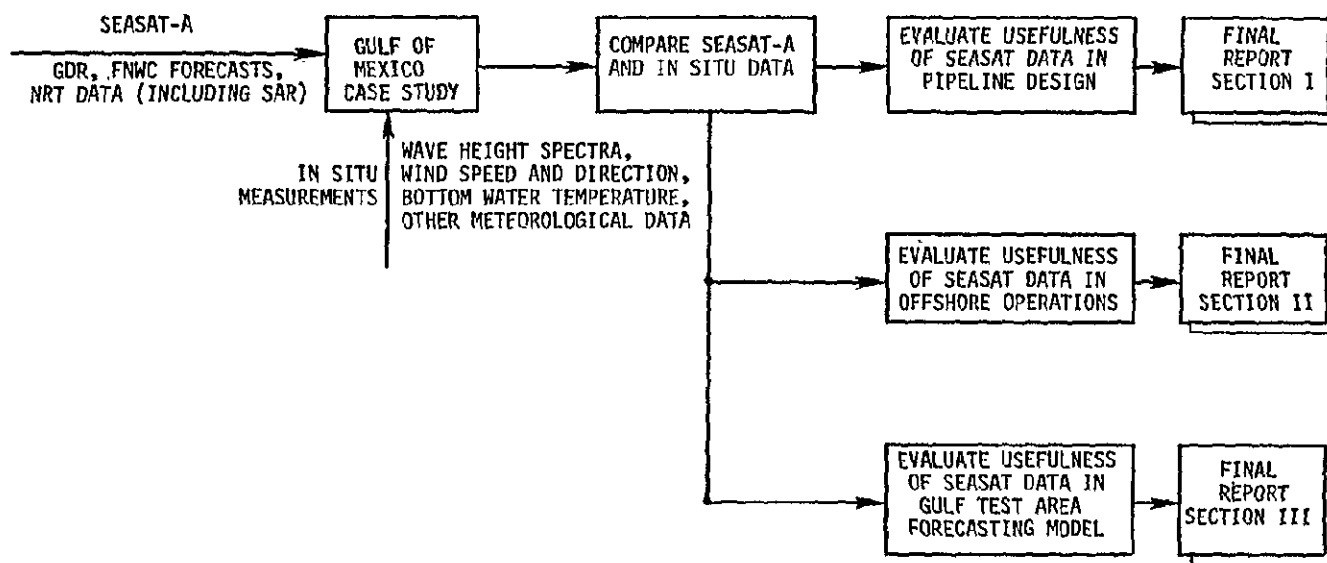


FIGURE 4 GULF OF MEXICO CASE STUDY

4.4.2 Case Study Manager

Name: Frank Rose
Address: CONOCO
P.O. Box 2197
Houston, TX 77001
Telephone: (713)-965-2614

4.4.3 Objective

The objective of this case study is to determine the applicability and benefit of SEASAT-type data for establishing design and operational criteria for offshore facilities. Figure 5 is an overview of the U.S. East Coast Case Study.

4.4.4 Data Needs

CONOCO has environmental data taken during the life of SEASAT on drillships operating in two locations:

1. Off the southwest coast of Sicily
2. Off the U.S. East Coast in the Baltimore Canyon.

CONOCO has also obtained and evaluated GEOS-3 data for Location 1 above. CONOCO will obtain from NASA SEASAT GDRs for both Locations 1 and 2 and four SAR passes for Location 2.

4.4.5 Analysis

CONOCO will use these data by validating sensor capabilities against their surface truth data and evaluate the forecasting value of the sensor data by using GDRs as input to forecasts. The resulting forecasts will be compared with existing (during the summer of 1978) forecasts.

4.4.6 Expected Output

Based on the forecast comparisons, the data will be assessed in terms of (1) meeting the above-mentioned objectives, and (2) potential benefits that could be derived, provided that an operational satellite system exists in the future.

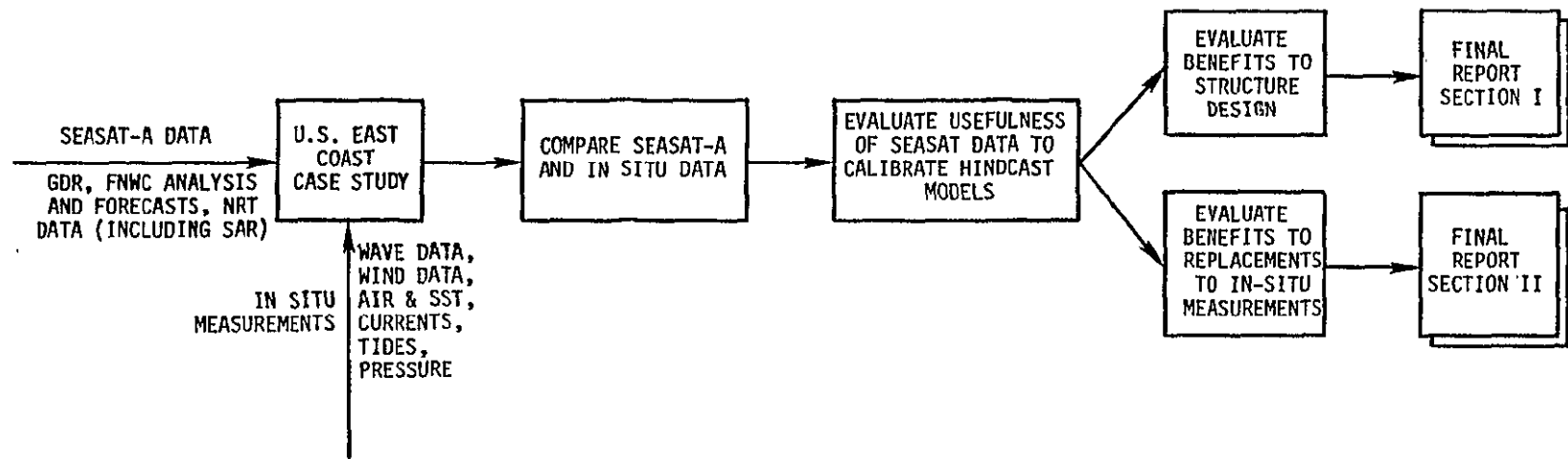


FIGURE 5 U.S. EAST COAST CASE STUDY

4.5 Worldwide Offshore Drilling and Production Operations (ASVT No. 5)

4.5.1 Participating Organization(s)

Name: Getty Oil Company
Address: 3903 Stoney Brook Drive
 Houston, TX 77042

4.5.2 Case Study Manager

Name: H.DeMirjian/P. Wybro
Address: Getty Oil Company
 3903 Stoney Brook Drive
 Houston, TX 77063
Telephone: (713)-782-7172

4.5.3 Objective

The objective of this case study is to assess the utility of SEASAT-type data for offshore oil and gas drilling and production operations. Figure 6 is an overview of the Worldwide Offshore Case Study.

4.5.4 Data Needs

Getty Oil Company (as operator for several other companies) has available detailed environmental data (winds, waves, pressure, temperature, currents) measured on the Discoverer Seven Seas drillship during July to October 1978 (during the life of SEASAT) in two areas:

1. Off Ibra Marino (Spain) from July 1 to July 23
2. The Straits of Ontranto (Italy) from August 3 to October 1.

4.5.5 Analysis

The SEASAT GDRs to be received from NASA will be used in Getty's SEASAT data evaluation case study to:

1. Validate sensor capability in comparing with surface truth
2. Evaluate the forecasting value of the sensor data by comparing them

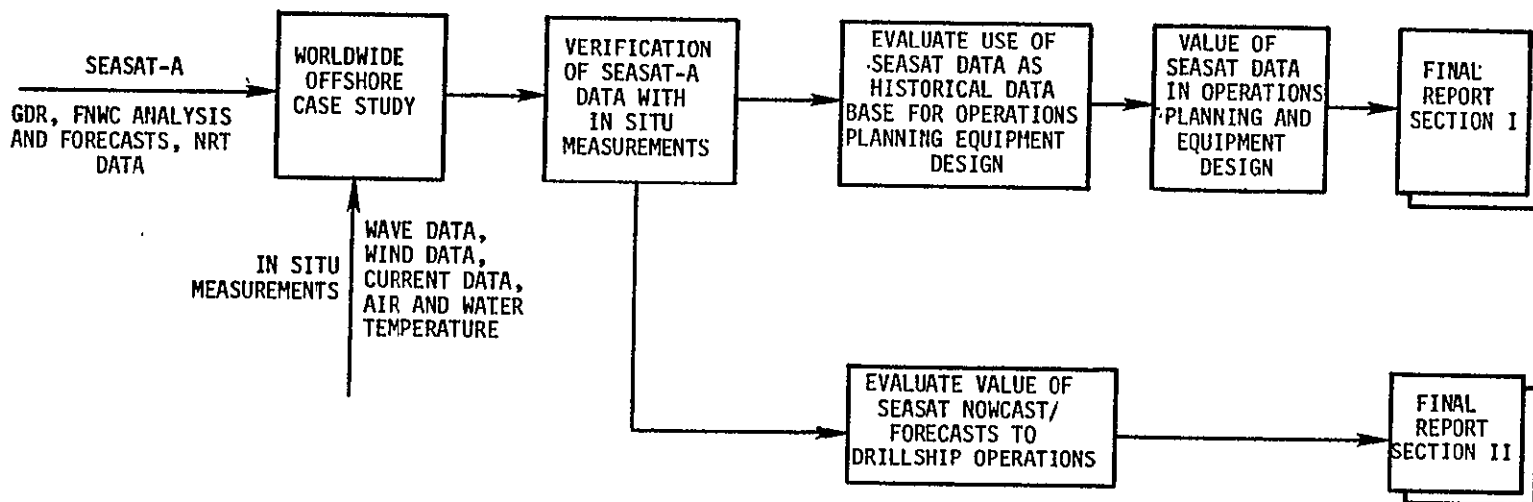


FIGURE 6 WORLDWIDE OFFSHORE CASE STUDY

with forecasting reports previously generated by Getty

3. Assess the use of SEASAT data in design (build an environmental data base)
4. Determine potential benefits that can be accrued based on a future operational satellite system that could provide SEASAT-type data.

4.5.6 Expected Output

TBS

4.6 Pacific Ocean Mining Case Study (ASVT No. 6)

4.6.1 Participating Organization(s)

1. Name: Deep Sea Ventures, Inc.
Address: Gloucester Point, VA 23062
2. Name: Ocean Minerals Company
Address: Lockheed Ocean Laboratory
3380 North Harbor Drive
San Diego, CA 92101
3. Name: Kennecott Exploration, Inc.
Address: 3377 Carmel Mt. Road
San Diego, CA 92121

4.6.2 Case Study Manager

1. Name: Bill Siapno
Address: Deepsea Ventures Inc.
Gloucester Point, VA 23062
Telephone: (804)-642-2121
2. Name: F.T. Lovorn
Address: Ocean Minerals Company
Lockheed Ocean Laboratory
3380 North Harbor Drive
San Diego, CA 92101
Telephone: (714)-298-8245

3. Name: A. Steen
Address: Kennecott Exploration Inc.
11095 Flintkote Avenue
San Diego, CA 92121
Telephone: (714)-453-3751

4.6.3 Objective

The objective of this case study is to assess SEASAT data utility for ocean mining design, exploration and operations. Figure 7 is an overview of the Pacific Ocean Mining Case Study.

4.6.4 Data Needs

Deep Sea Ventures, Inc. and Ocean Minerals Company were operating during the life of SEASAT-A and have available environmental data taken from their mining ships. In the same time period, SEASAT-A obtained data on near-record hurricanes in the Pacific ocean mining areas of interest.

4.6.5 Analysis

The surface truth data will be compared with the SEASAT-A GDRs in order to validate the SEASAT data. Environmental hindcasts will be prepared and compared with forecasts and surface truth measurements for the same time periods.

4.6.6 Expected Output

The degree of forecast enhancement possible using SEASAT-A data will be analyzed in order to obtain estimates of the applicability and benefits of SEASAT data for affecting decision processes during ocean mining operations.

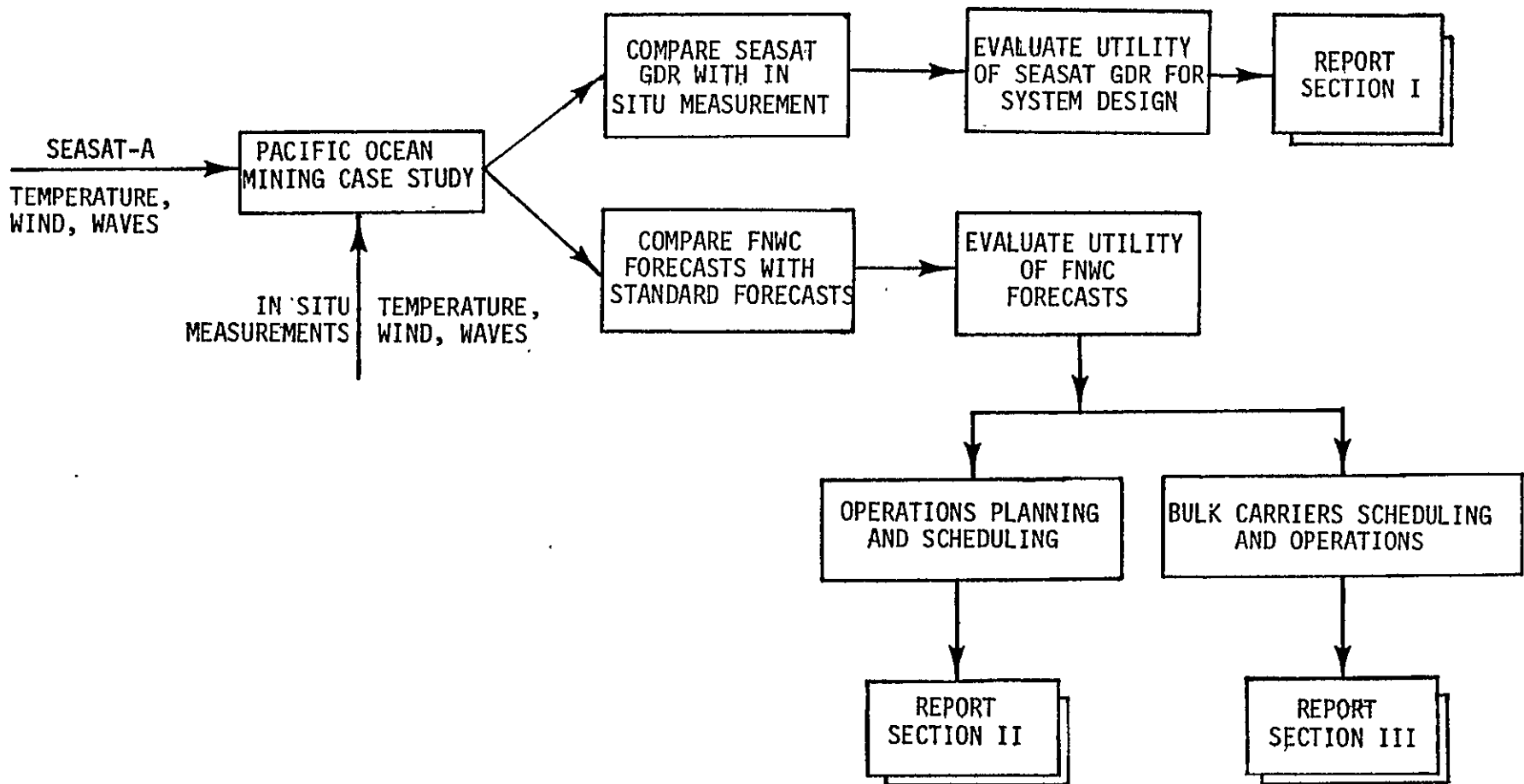


FIGURE 7 PACIFIC OCEAN MINING CASE STUDY

4.7 Bering Sea Case Study (ASVT No. 7)

4.7.1 Participating Organization(s)

Name: Oceanographic Services, Inc. (for AOGA/Bering Sea Ice Task Group)

Address: 135 East Ortega Street
Santa Barbara, CA 93101

4.7.2 Case Study Manager

Name: Mr. D.C. (Skip) Eckert

Address: Oceanographic Services, Inc.
135 East Ortega Street
Santa Barbara, CA 93101

Telephone: (805)-685-4521

4.7.3 Objective

Evaluate the use of SAR data for ice studies. Figure 8 is an overview of the Bering Sea Case Study.

4.7.4 Data Needs

Since, during the life of SEASAT, there were no ice conditions in the Bering Sea, SEASAT data would not be applicable. However, NASA LeRC plans to conduct ice measurements using microwave systems from aircraft during the winter and spring of 1979 in the Bering Sea. These aircraft data, similar to those from SEASAT, will be utilized by industry in their analysis and evaluation.

4.7.5 Analysis

TBS*

4.7.6 Expected Output

TBS

* Not available at present. To be supplied at a latter date.

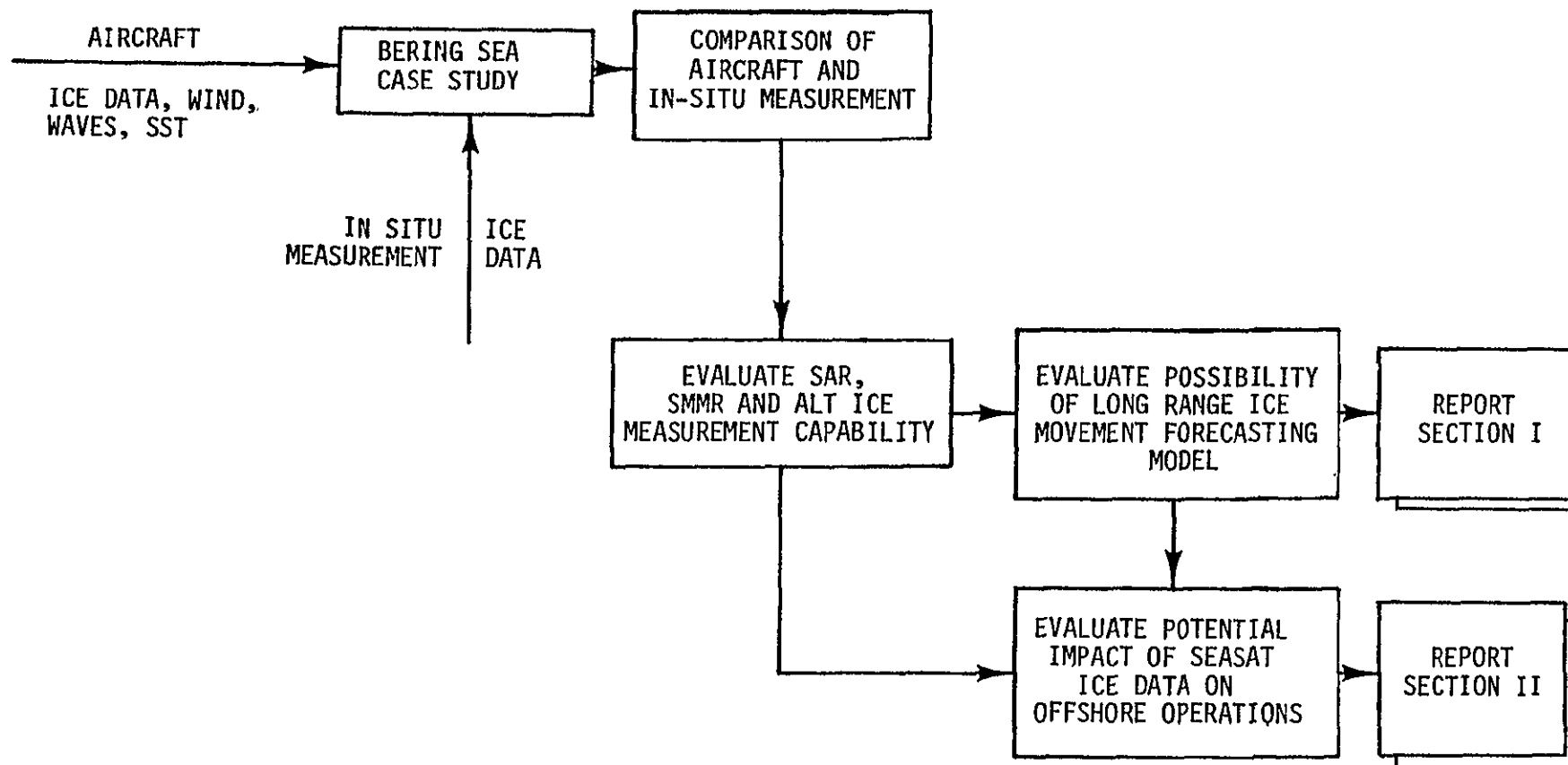


FIGURE 8 BERING SEA CASE STUDY

4.8 North Sea Case Study (ASVT No. 8)

4.8.1 Participating Organization(s)

1. Name: CONOCO

Address: R&D Department
Ponca City, OK 74601
2. Name: Union Oil Company

Address: P. O. Box 76
Brea, CA 92621

4.8.2 Case Study Managers

1. Name: Ronald Gratz

Address: CONOCO
R&D Department
Ponca City, OK 74601

Telephone: (405)-762-3456, ext. 4477
2. Name: Mike Utt

Address: Union Oil Company
P.O. Box 76
Brea, CA 92621

Telephone: (714)-528-7201

4.8.3 Objective

The objective of the North Sea case study is to determine the feasibility of using SEASAT-type data for improving on design of structures and assessing data utility for daily operations.

4.8.4 Data Needs

During the life of SEASAT, surface truth data were measured and collected from four instrumented ocean platforms/buoys. These data included winds, waves, temperature, atmospheric pressures and other environmental data.

4.8.5 Analysis

This case study will consist of analysis and validation of nonreal-time data. First, the available SEASAT GDRs (taken within a 100 km diameter of each

platform) on waves, winds and temperatures will be analyzed; then, these data will be compared with weather conditions known to exist at that time. A forecast analysis will be made to determine what could have happened had GDR data been available at that time. Finally, SEASAT data will be compared with the collected surface truth data, and an evaluation made as to the utility of similar types of data available from future satellite programs.

4.8.6 Expected Output

The SEASAT-A data will be evaluated for possible use in a system to forecast high waves and winds. Estimates will be made of the potential improvement in weather forecasts and the possibility of establishing a long-term data base to predict extreme environmental conditions will be evaluated.

4.9 Marine Environmental Forecasting in the North Sea (ASVT No. 9)

4.9.1 Participating Organization(s)

Name: Ocean Routes, Inc.
Address: 3260 Hillview Avenue
Palo Alto, CA 94034

4.9.2 Case Study Manager

Name: Dan Bertonneau
Address: Ocean Routes Inc.
3260 Hillview Avenue
Palo Alto, CA 94304
Telephone: (415)-493-3600

4.9.3 Objective

The overall objective of this case study is to evaluate the technical utility and possible economic benefits of applying SEASAT data to weather forecasting in support of offshore energy exploration and production activities. Figure 9 is an overview of the Marine Environmental Forecasting Case Study.

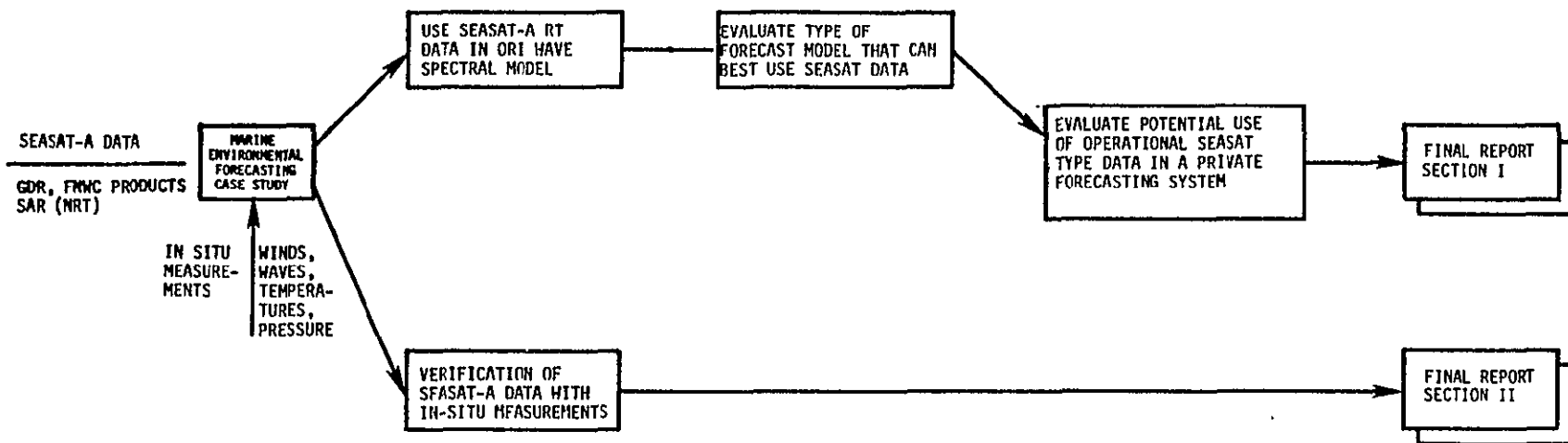


FIGURE 9 MARINE ENVIRONMENTAL FORECASTING CASE STUDY

4.9.4 Data Needs

The data needs for this study are the SEASAT-A GDRs for winds and waves in the North Sea.

4.9.5 Analysis

The SEASAT data on marine winds and waves will be input into a fine grid ocean wave spectral model for the North Sea to determine if forecasts are improved. Analyses will also be performed to determine what type of forecast model can best utilize the SEASAT data. The SEASAT data will be compared with recorded measurements taken from semi-submersible drilling platforms and other vessels in the North Sea to establish a ground truth reference basis. This case study will also investigate how SEASAT type sensor data can be integrated into a private forecasting system if planned follow-on ocean satellites become a reality.

4.9.6 Expected Output

Assessments will be made, based on the results of this study, as to the value of SEASAT data for improving weather forecasting in the North Sea. The potential economic benefits of these improvements will also be investigated.

4.10 Ocean Thermal Energy Conversion (ASVT No. 10)

4.10.1 Participating Organization(s)

Name: Ocean Data Systems, Inc.

Address: 2400 Garden Road
Monterey, CA 93940

4.10.2 Case Study Manager

Name: Paul Wolff

Address: Ocean Data Systems, Inc.
2400 Garden Road
Monterey, CA 93940

Telephone: (408)-373-2011

4.10.3 Objective

The objectives of this case study are to evaluate the utility of SEASAT data to support Ocean Thermal Energy Technology in the following areas: (1) to determine diurnal variations in the sea surface temperature in unexplored regions where thermal energy plants will operate, (2) to apply SEASAT data to the development of improved weather forecasts of extreme wind and wave conditions which might affect plant operations, (3) to detect changes in the sea surface temperature caused by the operation of thermal energy conversion plants. Figure 10 is an overview of the OTEC Case Study.

4.10.4 Data Needs

This study will require SEASAT-A GDRs containing winds, waves and sea surface temperature for possible OTEC plant locations.

4.10.5 Analysis

The SEASAT data will be integrated into the existing marine data base to determine its ability for producing improved forecasts in regions conducting ocean thermal energy activities. An evaluation study will be performed to determine how to best incorporate the satellite data into existing synoptic data bases. Sea surface temperature data will be used to perform resource mapping of the ocean surface for energy plants. The SEASAT data will be evaluated for accuracy by comparisons with surface truth data acquired on operating energy plants.

4.10.6 Expected Output

The results of this case study will be used to provide an assessment of the utility of future ocean satellites to support Ocean Thermal Energy Conversion technology developments.

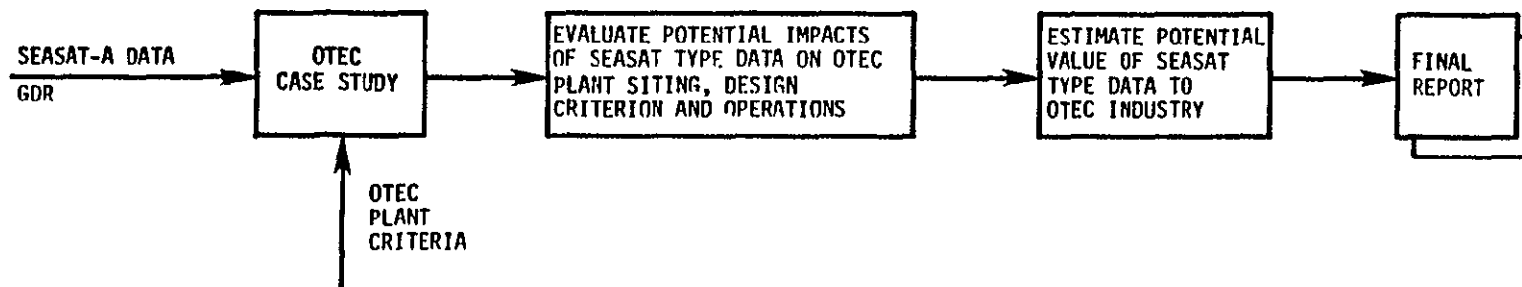


FIGURE 10 OTEC CASE STUDY

4.11 Optimum Ship Routing (ASVT No. 16)

4.11.1 Participating Organization(s)

Name: Ocean Routes, Inc.
Address: 3260 Hillview Avenue
Palo Alto, CA 94034

4.11.2 Case Study Manager

Name: Dan Bertonneau
Address: Ocean Routes, Inc.
3260 Hillview Avenue
Palo Alto, CA 94304
Telephone: (415)-493-3600

4.11.3 Objective

The objective of this case study is to evaluate the technical and economic impact resulting from the integration of SEASAT data into weather products and dynamic models used in ship routing. Figure 11 is an overview of the Optimum Ship Routing Case Study.

4.11.4 Data Needs

TBD

4.11.5 Analysis

Global weather forecasting products will be developed which use SEASAT data in their Primitive Equation Model. These will be compared to products developed from present-day data sets and to surface truth to determine if the forecasted weather and sea conditions improve as a result of the SEASAT data. Ship routing selections will be developed using computer programs which take the predicted sea state conditions as input. Predicted weather, sea state and ship performance data will be simulated and compared with actual operational data to establish accuracy levels. The impact of SEASAT-type data will also be evaluated for making short-term forecasts to optimize routes of ships already in transit.

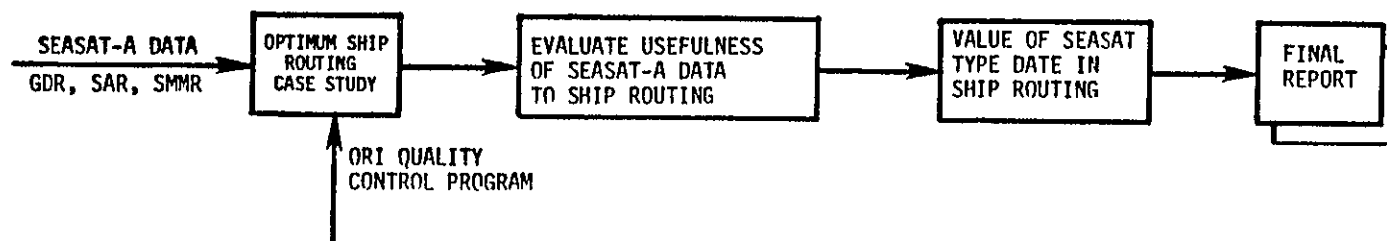


FIGURE 11 OPTIMUM SHIP ROUTING CASE STUDY

4.11.6 Expected Output

The results of the phases of this case study will be used to assess the utility and possible economic benefits to ship operators of improved routing information derived from SEASAT data.

4.12 Improved Weather Forecasting (ASVT No. 22)

4.12.1 Participating Organization(s)

Name: Atmospheric Environmental Service
Address: 4905 Dufferin Street
Downsview
Toronto, Ontario
Canada M3H 5T4

4.12.2 Case Study Manager

Name: Dr. Steven Peteherych
Address: Atmospheric Environmental Service
4905 Dufferin Street
Downsview
Toronto, Ontario
Canada M3H 5T4
Telephone: (416)-667-4815

4.12.3 Objective

The objective of this case study is to evaluate the impact of SEASAT data in the development of operational forecasts in the Canadian offshore areas. The specific study objectives are to: (1) evaluate the utility of the SEASAT data in improving regional ocean analyses, (2) evaluate the impact of SEASAT data on developing improved regional forecast products, (3) evaluate SEASAT data in comparison with surface truth data, (4) evaluate SEASAT SAR data in the regions of the Canadian Arctic to determine its ability to yield information about ice cover. Figure 12 is an overview of the Improved Weather Forecasting Case Study.

4.12.4 Data Needs

TBS

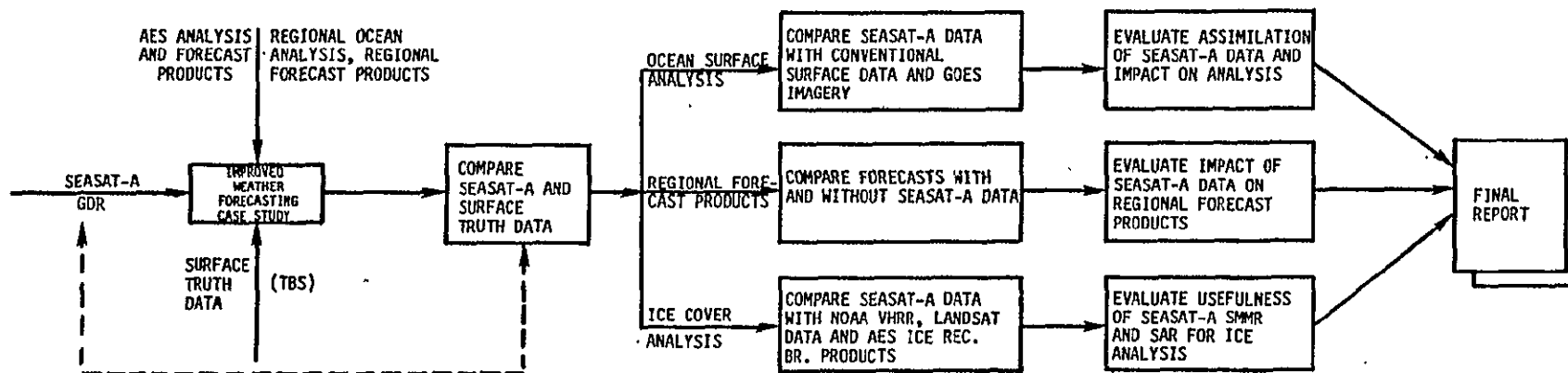


FIGURE 12 IMPROVED WEATHER FORECASTING CASE STUDY

4.12.5 Analysis

This case study will develop a set of analysis and forecast products, with and without SEASAT data, to support the case study objectives of the Beaufort Sea (ASVT No. 1) and Labrador Sea (ASVT No. 2) experiments. Methods will be studied for assimilating the nonsynoptic data from SEASAT with those of ocean-based sensors. Sensor density, interpolation methods, and data product grid size will be evaluated in the context of the SEASAT data.

4.12.6 Expected Output

The results from this case study will be used to assess the value of SEASAT data in improving the quality of regional weather forecasts. The related impact of SEASAT sensor types on conventional synoptic forecasting technology will also be studied.

5. ANALYSIS AND INTEGRATION OF THE CASE STUDY RESULTS

This section describes the support to be provided to the individual case studies in the analysis of the case study results, and the analysis of the results of all of the case studies as a totality to obtain estimates of the economic and operational impacts of SEASAT type data on ocean-based commercial activities.

Figure 13 illustrates the flow of the analysis and integration of the case study results. The two significant outputs of this process, the Estimate of Case Study Benefits and the Implications of Case Study Results are highlighted in this figure. Each step in the process shown in Figure 14 is described in the following paragraphs.

5.1 Support to Individual Case Studies

An objective of each case study is to assess the utility of SEASAT data to the particular operations conducted in that case study. Within each case study it is intended that the case study team perform this assessment of the utility of SEASAT data. Ideally, it is desired that the case study team assess the utility of SEASAT data in terms of the operational and/or economic impacts produced by the SEASAT data in the case study. On the other hand, because of resource limitations or lack of experience it may not be possible for the case study team to plan the case study methodology to identify the operational and/or economic impacts of the SEASAT data, or to perform the analysis that will yield the estimates of these impacts. Where the need for specific assistance is identified in either the planning or performance of the case study, and such assistance is requested by the case study team, JPL and/or its contractors will provide the requested assistance.

5.2 Case Study Results

As shown in Figure 14, each case study will consist of an in-depth evaluation

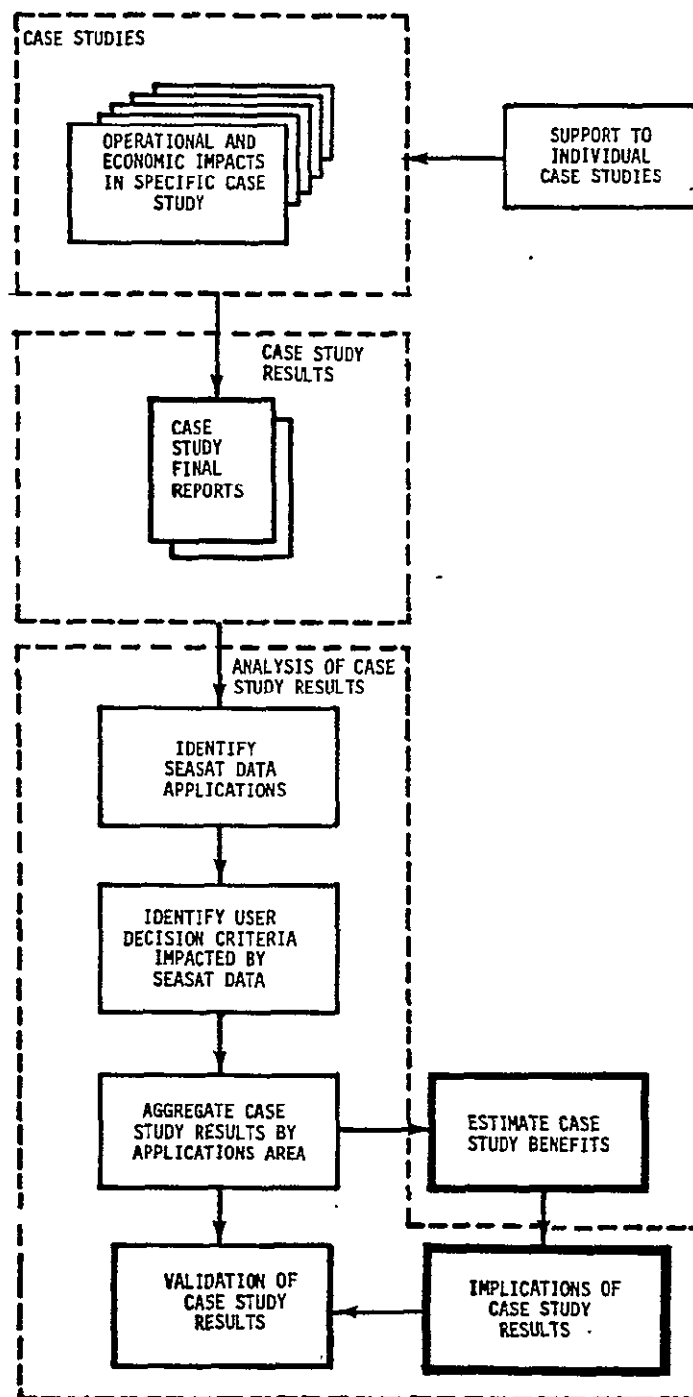


FIGURE 13 ANALYSIS AND INTEGRATION OF THE CASE STUDY RESULTS

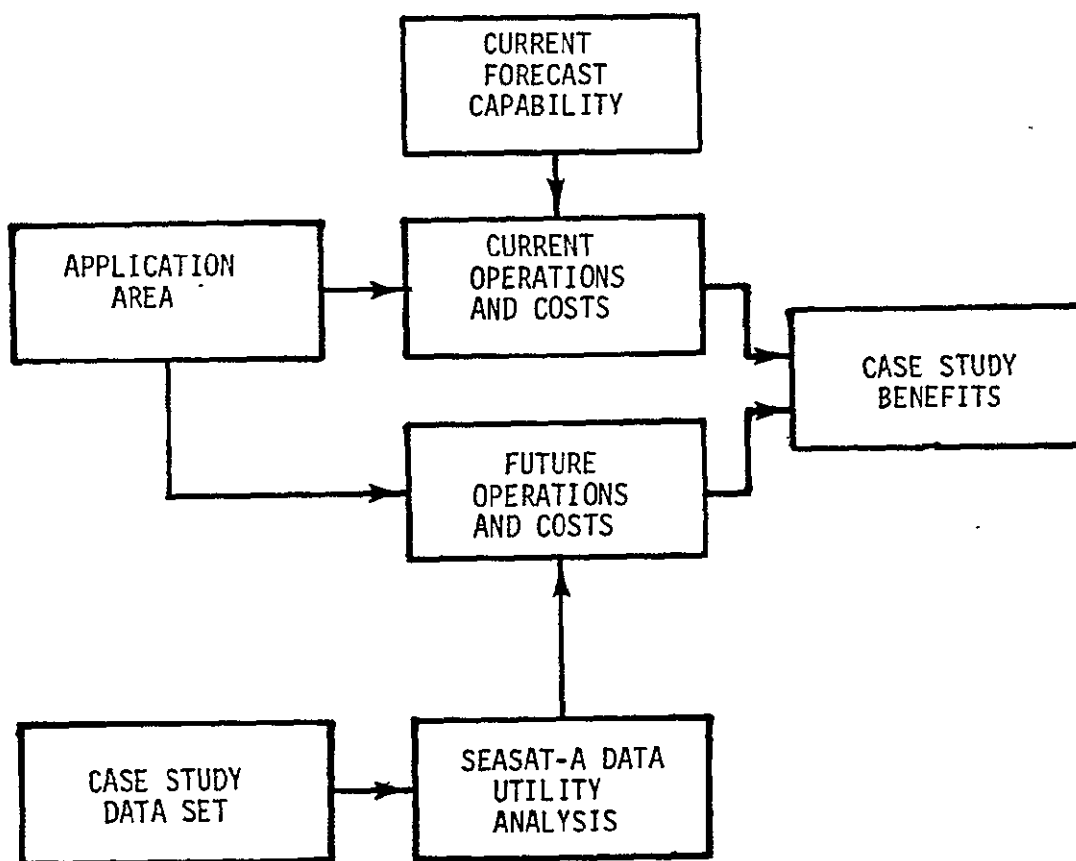


FIGURE 14 CASE STUDY METHODOLOGY

of the potential benefits that might be obtained from the use of SEASAT data in a specific application[4]. The application(s) to be studied will be selected by the case study team in consultation with NASA/JPL. The case study team will be responsible for performing the analysis. The case study data set will consist of SEASAT-A data in the specific geographical locale(s) pertinent to the case study. In most instances the case studies will be performed in the classic manner of a benefit/cost study; i.e., the cost and benefits will be examined under two conditions, namely:

1. With the current ocean condition and weather forecast capability
2. With the forecast capability demonstrated by SEASAT-A (or expected from an operational system with similar capabilities to SEASAT-A).

The results of each case study, as completed by the case study team, will be documented in a case study final report. Each case study final report will be written and published by the case study team that has performed that study. While the contents of the final report will be determined by the nature and requirements of the case study, the goal of the case studies (to evaluate the operational or economic impacts of the SEASAT-A data) must be borne in mind in the performance of the case study and the documentation of the case study results. Toward this end, a suggested case study final report outline, and specifications for the report content is provided in Appendix B.

5.3 Analysis of Case Study Results

The objective of this stage of the analysis is to obtain a consistent set of benefit estimates for each case study. Based upon the results of the case study, it is intended that the benefit estimate at this level clearly identify the potential uses of SEASAT data supported by the case study, the decision criteria impacted by SEASAT data in the case study and the estimate of operational and/or economic impacts of the SEASAT data within the context of the case study.

5.3.1 Applications and Decision Criteria

In this step, the results of each case study will be examined to identify specific applications and decision criteria impacted by SEASAT data. As the case studies will be constrained to the period of roughly July through early October 1978, it is likely that certain applications and decisions may have occurred during this time period, while the possible application of SEASAT data to other decision criteria may only be implied by the results of the case studies. Both actual and implied applications and decisions will be identified from the case study results.

5.3.2 Aggregation of Case Study Results

The case study results will be aggregated by application area (such as marine transportation, offshore oil and gas exploration, and development). The aggregated result can be visualized as a matrix of data products and decisions for each application area, where the entry in the matrix represents the case study estimate of the impact of the specific data product on the decision. The analysis of the case study results will be completed by producing an estimate of the economic benefits indicated in each case study, and compiling an aggregation of case study benefit estimates by application area, data product and data use.

5.4 Estimate of Case Study Benefits

The estimate of case study benefits will constitute the first major output of the analysis process. Since the case study teams have varying degrees of analytical capability it is anticipated that the case study teams will not all complete the same extent of analysis. Some of the case studies may be carried through to estimates of costs and benefits, others may describe the results in terms of expected operational impact (such as reduction in downtime, reduction in crossing time), while others may describe the impacts of the SEASAT data in qualitative terms. Using the data from the case studies, and publically available industry data

on operating costs and losses, the results of the individual case studies will be extended (as required) to provide quantitative benefit and cost estimates.

5.5 Implications of the Case Study Results

The final step in the analysis of the case studies will be to evaluate the implications of the case study results. In this step an effort will be made to arrive at specific recommendations for steps that could be taken by the various federal agencies involved in the development of ocean data collection and dissemination systems, and by the users of the data provided by these systems to improve the usefulness of future systems to commercial and industrial users.

It is anticipated that the results of the case study analysis program will be validated in individual meetings with the case study teams and in a final workshop involving the case study teams and other interested public and private sector participants.

REFERENCES

1. The First SEASAT-A Industrial Users Workshop, Contract NASW-3047, ECON, Inc., February 10, 1978.
2. SEASAT-A ASVT Commercial Demonstration Experiments, User Requirements Document, Jet Propulsion Laboratory, 622-92, September 1, 1978.
3. Status of the SEASAT Commercial Demonstration Program: A Report on the Workshop Held at the Jet Propulsion Laboratory on October 31 and November 1, 1978, ECON, Inc., December 1978.
4. SEASAT Economic Assessment, ECON, Inc., August 31, 1976.

APPENDIX A

THE SEASAT-A DATA SET*

Satellite Data Set

The acquisition of both satellite and surface truth data is summarized graphically in Figure A.1, while the SEASAT-A sensor measurement objectives are summarized in Table A.1. For the SASS and SMMR, data were collected continuously between days 188 and 283. The VIRR scan motor failed on day 240, while the altimeter data set was interrupted on two occasions for nine days each. A significant amount of full sensor complement data was obtained during the major surface truth activities, as well as several times at which the satellite encountered storms. The coverage obtained by the Synthetic Aperture Radar is shown in Figure A.2. Virtually complete coverage was obtained for the North American continent, Alaska and adjacent waters. Coverage for the foreign stations (Shoe Cove and Oakhanger) was less complete, but critical experiment areas did receive coverage.

The ground trace pattern achieved by SEASAT is depicted in Figures A.3 and A.4. There were three periods of orbital operation, the results of which can be seen on the figures. The initial or launch orbit provided the intermediate grid visible in Figure A.3. The final or Bermuda orbit produced a large grid with several repeats at each orbital position (Figure A.4).

Note that in Figure A.1 that, in the interval between launch and day 230 (mid-August), no orbit adjusts were made. The decision to leave the initial orbit unadjusted resulted in large measure from the "Cambridge-like" character of the launch orbit. The Cambridge orbit, favored by many of the SEASAT Experiment

* Taken from The SEASAT Mission Report, revised 2/19/79, JPL.

TABLE A.1 SEASAT MICROWAVE SENSOR MEASUREMENT OBJECTIVES

<u>ALTIMETER</u>	<u>SASS</u>
1. Range (height) precision ± 10 cm (1 σ , 1 s average)	1. Wind speed from 4 - > 26 m/s, \pm m/s or 10%
2. Ocean topography solutions on submeter level	2. Wind direction ± 20 deg
3. $H_{1/3}$ (significant wave height) from 1-20 m, $\pm 10\%$ of 0.5 m	3. 50 km resolution, 500 km swath each side of satellite
4. σ_0 (backscatter coefficient) ± 1 dB	
5. Precision orbit determination to submeter level globally, 10 cm in the calibration zone.	
	<u>SAR</u>
	1. 25 x 25 m spatial resolution over 100 km swath
	2. Demonstrate capability to measure wave length and direction
	3. Provide data for the study of coastal processes
	4. Ice field/lead charting
	5. Iceberg detection
	6. Fishing vessel surveillance
	7. Land imaging for geological, hydrological and glaciological experiments.
<u>SMMR</u>	
1. All weather global measurement of sea surface temperature, $\pm 2^\circ$ K absolute, $\pm 0.5^\circ$ K relative	
2. Wind speed from 7-50 m/s, ± 2 m/s or 10%	
3. Measurement of integrated atmos- pheric water vapor and liquid water	
4. Measurement of rain rate.	

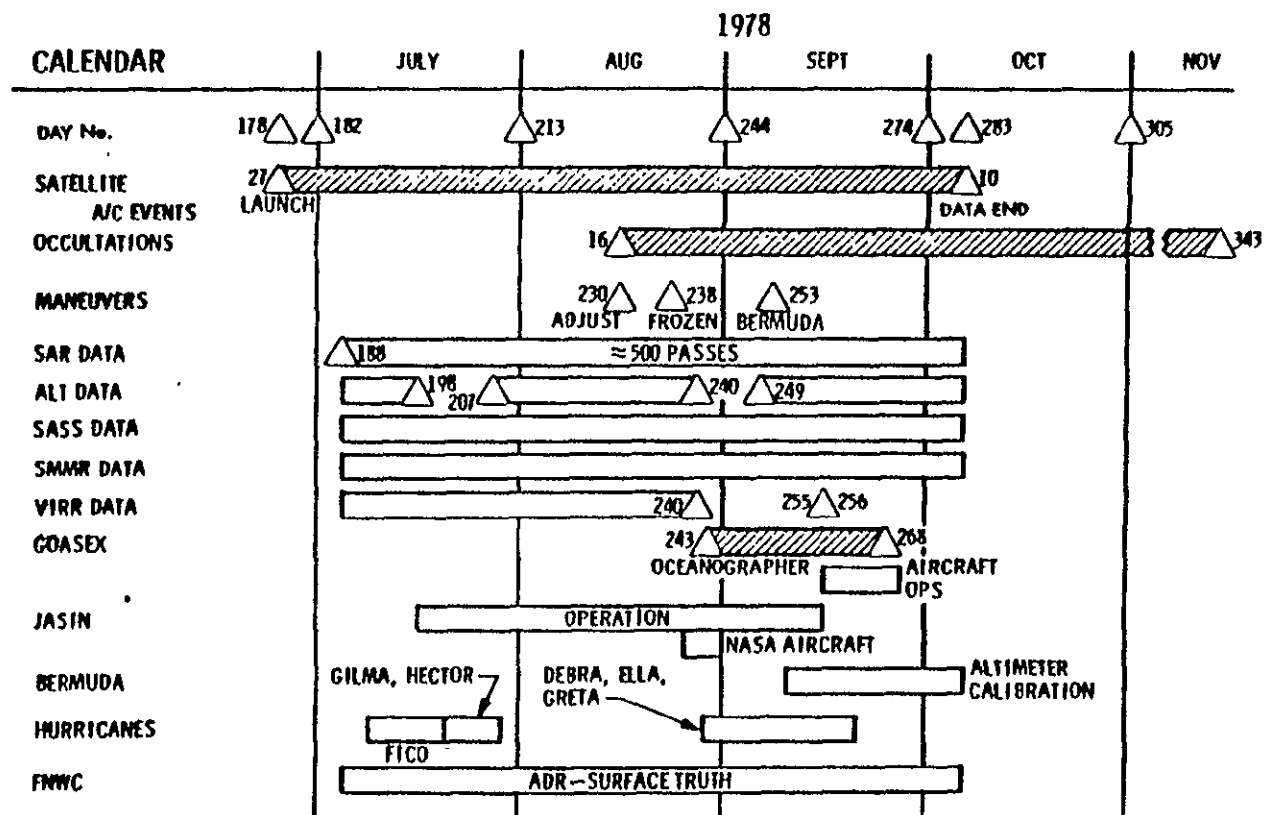


FIGURE A.1



SEASAT SAR

3 JULY THRU 10 OCTOBER, 1978

REVS 107 TO 1502

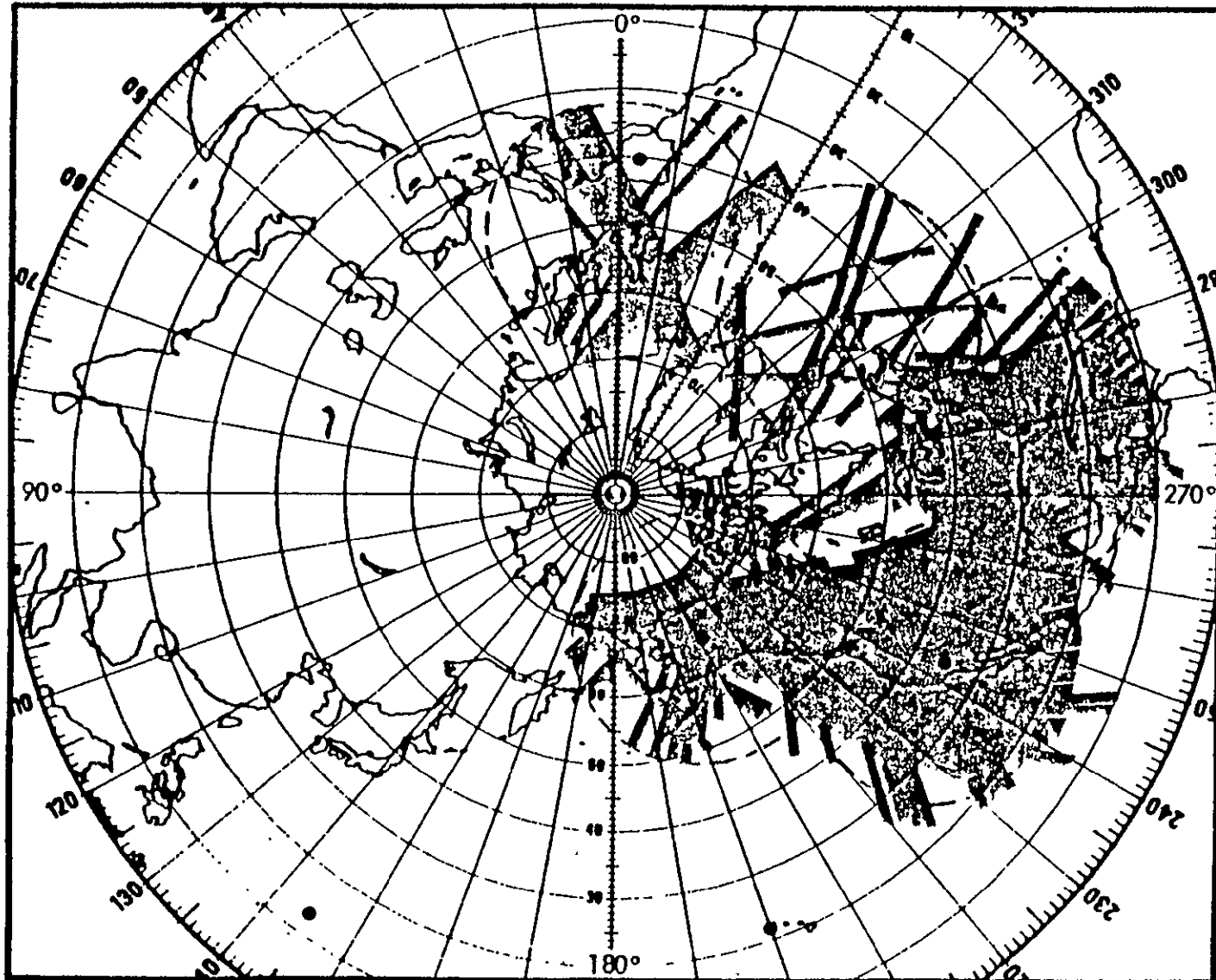


FIGURE A.2

SEASAT-A LAUNCH ORBIT 17DAY COVERAGE

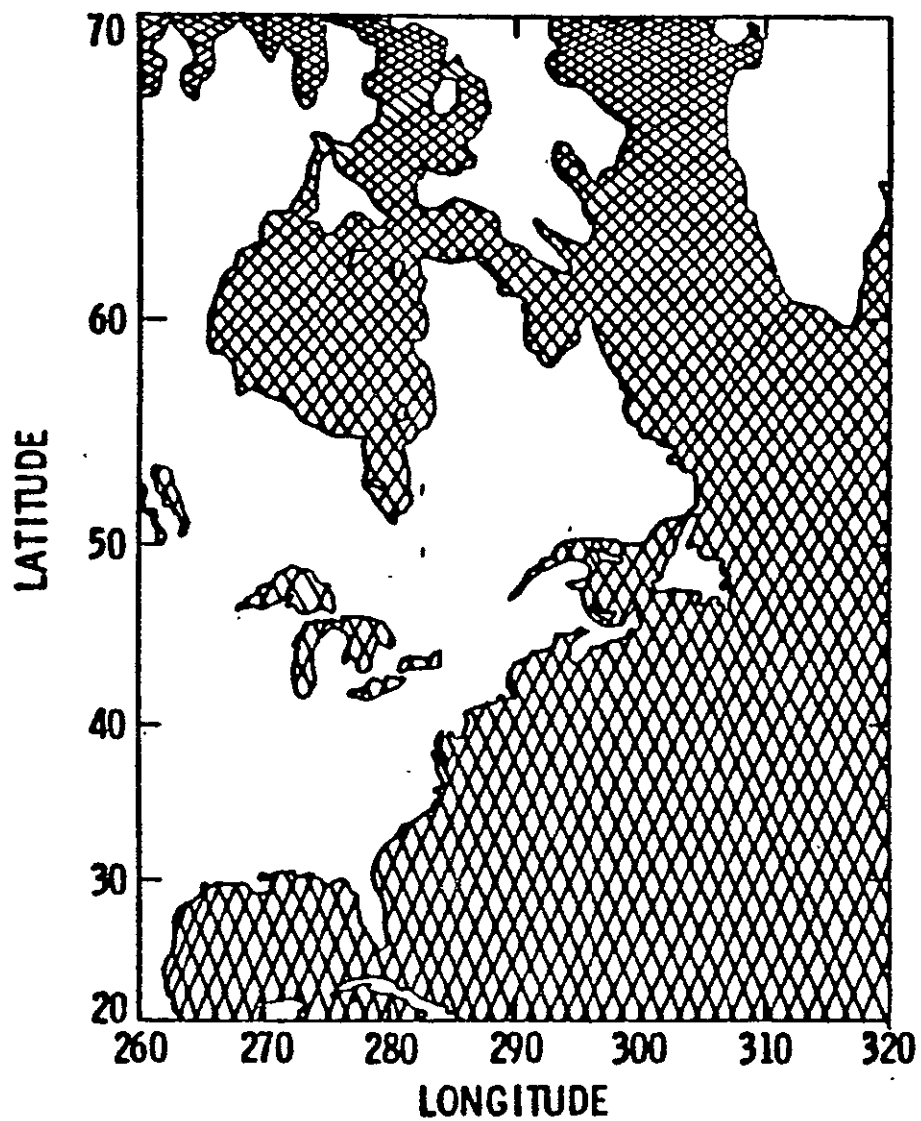


FIGURE A.3

SEASAT-A BERMUDA OVERFLIGHT 3 DAY COVERAGE

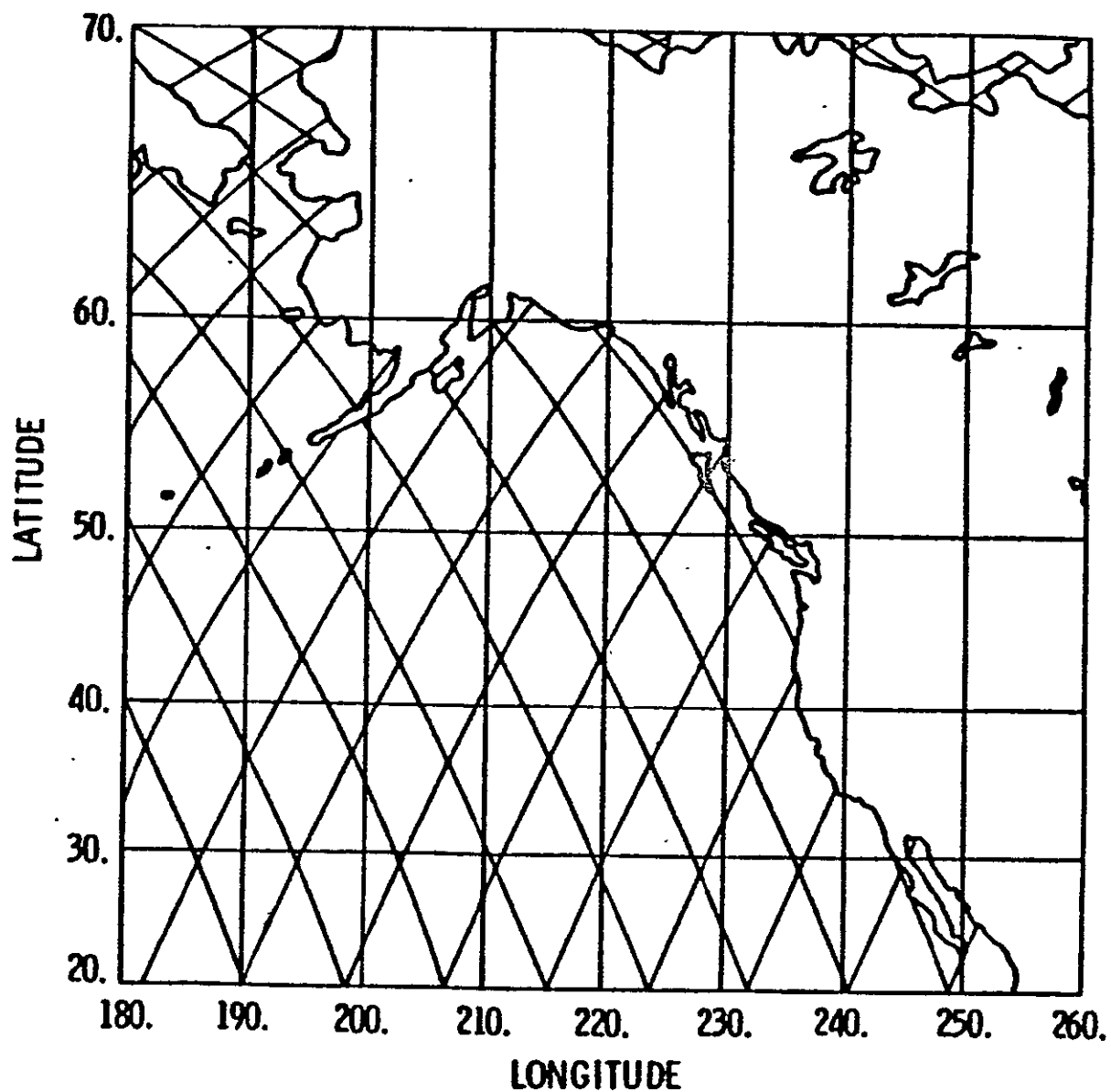


FIGURE A.4

Team members, has the property of generating an approximate 1 degree subsatellite track spacing every three weeks, providing rapid global sampling at a grid size intermediate between the three day separation (approximately 900 km) and the final, 152-day geodetic grid, a dense network with 18-20 km spacing at the equator. The launch orbit had a 17-day closure at 1.67 degree subsatellite track spacing, and two geodetic cycles were completed in the first month and a half of the mission. The Bermuda orbit, entered on day 253, provided an exact three-day repeat with the satellite passing directly over the island of Bermuda. This characteristics permitted near zenith ranging from the laser site on Bermuda for the purpose of calibrating the radar altimeter. A tide gauge, accurately surveyed relative to the tracking station, provided a precise tie to the sea surface in the vicinity of the island.

The fact that both a survey and a repeating orbit were achieved during the satellite operational period enhances the value of the data set collected, in that both rapid global sampling and repeated coverage (useful for the study of deep ocean circulation phenomena, for example) were obtained, a nearly optimal situation given the duration of the operational period. It should be noted that preflight experiment planning called for both a baseline and Cambridge orbit during the first mission year.

Surface Truth Data Set

Surface truth data acquired in support of sensor geophysical evaluation falls into three categories: routine, special experiments and extreme conditions.

Routine Data

The Navy's Fleet Numerical Weather Central (FNWC) is supporting the SEASAT data analysis activity by providing all surface reports and selected field data in the form of a computer-compatible tape called the auxiliary data record

(ADR). This invaluable data base includes hundreds of wind, sea satate, sea and air temperature reports daily for mission period. NOAA's National Environmental Satellite Service (NESS), in addition to coordinating special experiments (see below), provided important support in two other areas. First, there was the cooperative vessel program, in which dozens of vessels provided surface observations at satellite overpassage times, using a printed log and accompanying satellite position calculator. This package was designed and distributed by NESS, with the support of the SEASAT Project. A second important additional data type provided by this service is a complete set of daily meteorological satellite visible and infrared imagery for the SEASAT operational period. This imagery produced by the geostationary satellites, GOES East and West, is particularly valuable in identifying and locating satellite observation of extreme conditions.

Special Experiments

As had long been planned, the Project cooperated in and conducted, respectively, two major surface experiments during August and September. The first of these was the multi-national Joint Air-Sea Interaction Experiment (JASIN), which was conducted in the Eastern Atlantic near Scotland. An intensive study of the marine boundary layer and air-sea energy transfer was planned and conducted by a group of European and American scientists. JASIN provides a source of high-quality surface truth data, most of which will be acquired for SEASAT experiments by way of data exchange agreements. A lead role in obtaining these agreements has been played by a group of European investigators with an interest in SEASAT data (the SEASAT Users Research Group in Europe, headed by Dr. Tom Allen of the Institute of Oceanographic Sciences, Wormley, United Kingdom). Some 200 SEASAT passes were obtained over the JASIN area during the experiment

period. A NASA C-130 aircraft, equipped with a SEASAT underflight scatterometer built by Langley Research Center, participated, along with several European and American research aircraft.

A SEASAT-dedicated experiment was conducted in September in the Gulf of Alaska. Termed the Gulf of Alaska SEASAT Experiment (GOASEX), this activity was planned and conducted by the National Oceanographic and Atmospheric Administration (NOAA), including the Pacific Marine Environmental Laboratory (PMEL), NESS, the Atlantic Oceanographic and Meteorological Laboratory (AOML), the Wave Propagation Laboratory (WPL), and the National Data Buoy Office (NOBO). The principal research facility deployed during GOASEX was NOAA's Class 1 Research Vessel Oceanographer. The Canadian weather ship Quadra and Vancouver, alternating at Ocean Weather Station PAPA, also obtained special data at satellite overpass times. Participating aircraft included the Ames Research Center's CV-990 equipped with an airborne version of the SMMR, the Johnson Space Center's MC-130B with the SEASAT underflight scatterometer, the Naval Research Laboratory's RP-3A equipped with meteorological and microwave radiometer instrumentation, and the Canadian CV-580A aircraft carrying the Environmental Research Institute of Michigan's synthetic aperture radar system. A very comprehensive data set was collected, corresponding to some 60 satellite overpass, including more than a dozen SAR passes. An intensive, coordinated study of this data set is planned as a key element in the early evaluation activity.

Extreme Conditions

The observation of high wind and seastate conditions require collecting data in several storms. It is fortunate that SEASAT data was obtained over dozens of hurricanes, typhoons and tropical storms in the Atlantic, Pacific and Gulf of Mexico. Furthermore, many of these were observed simultaneously or nearly so by

aircraft, surface vessels and meteorological satellites. An example of SEASAT surface truth data obtained on a hurricane is the data set collected on Hurricane FICO during July. During the interval 7 to 20 July, this storm was observed repeatedly, as it moved to the west from the longitude of Baja California to a region west of Hawaii. SAR images obtained over the central region of the storm on July 7 have yielded sea surface and wave imagery in regions undetected using visual or infrared sensors, and should provide an otherwise unobtainable data set useful to a study of wave generation and propagation in cyclonic storms. The hurricane was observed by the scatterometer some three weeks later near Hawaii. A good surface truth data set is available for this observation in the form of meteorological aircraft and ship reports, as well as cloud motion measurements using meteorological satellite imagery. The comparisons made to date between the surface truth data and the SASS-derived winds show a good correlation for this storm. FICO also yielded extreme condition observations for the SMMR, altimeter and VIRR. SMMR data will provide a comparison to SASS winds and, more importantly, a well-documented test case for SASS path attenuation and altimeter refraction corrections. For the altimeter, FICO and similar intense storms will provide data on significant wave height ($H_{1/3}$) for the upper end of the measurement range.

APPENDIX B

SEASAT-A ASVT CASE STUDY FINAL REPORT OUTLINE

The following is a suggested outline for the final reports for the case studies. It may be necessary to modify this outline to suit the requirements of the particular case study. The suggested outline covers some of the most important questions which the Commercial Demonstration Program attempts to respond to in the evaluation of the SEASAT-A data.

SEASAT-A ASVT
SUGGESTED CASE STUDY FINAL REPORT OUTLINE

Abstract

1. Executive Summary

A two to five page overview with emphasis on results, economic or operational impacts of data, conclusions or recommendations.

2. Case Study Objective

What is your specific objective or purpose for performing this case study?

3. Case Study Description

3.1 Geographic Locale

What was the geographical location of the case study? If fixed platforms were used, where were they located? If ships were used, what routes did they follow? If possible, use a map to illustrate locations. If this data is considered to be proprietary, approximate location will suffice.

3.2 Time Period of Case

When did you begin the operations involved in the cost study, and when did you stop operations? If you took surface truth data, what were the dates or time periods for acquisition of surface truth data? Give dates of significant events that occurred during the case study.

3.3 Nature of Operations Conducted During Case Study

Describe the specific operations that you performed during the case study. For example, if ships were used in the case study, what were they used for and how were they used? If surface truth data was taken, describe how the surface truth data was obtained.

3.4 Equipment Used in Case Study

Describe the equipment used in the case study. Use photographs or sketches to supplement a written description.

3.5 SEASAT-A Data Received

What SEASAT-A data did you receive?

3.6 In Situ Data Measurements

This section is applicable only if you made in situ or surface truth measurements. Describe the nature of the measurements made and provide examples of data taken.

4. Results Obtained

4.1 Evaluation of SEASAT-A Data

Evaluate the quality of the SEASAT-A data that you received. If you took surface truth data, how did the SEASAT-A data compare to the surface truth? How did the SEASAT-A data compare to data that you received from other sources? How did the SEASAT-A data compare to your experience?

4.2 Impacts of SEASAT-A Data on Operations

What did you do with the SEASAT-A data that you received during the case study? How would the data have been used within your operations? Could the SEASAT-A data have been used in any decision processes during the case study? Describe the decision processes and any impact that the SEASAT-A data might have had on the decisions.

5. Utility of the SEASAT Data

5.1 Utility of SEASAT-A Data in Current Operations

What could the usefulness of SEASAT-A data be in your current operations? Describe the decision processes that could be affected by the SEASAT-A data. Quantify the effect of SEASAT-A data on your current operations. For example, could SEASAT-A data reduce costs or losses in your current operations? If possible, quantify the reductions.

5.2 Potential Utility of SEASAT Type Data in Future Operations

What is the potential usefulness of SEASAT type data to your future operations (of the type involved in this case study)? Do you believe that it will be possible to use SEASAT type data in system design? What are the future operations and what decisions in these operations could be impacted by an operational SEASAT type system? Quantify the usefulness of SEASAT data on future operations to the maximum extent possible.

5.3 Changes Needed to Improve Utility of Future Systems

On the basis of this case study, what changes in the SEASAT system do you see as necessary to improve the usefulness of SEASAT data to your future operations? Do you require other kinds of data? In a different format? How would you use this additional data?

6. Conclusions

What conclusions do you draw from this case study relative to the usefulness of SEASAT data in your present and future operations?

7. Recommendations

What are your recommendations to NASA concerning future systems developments or experiments? Specifically, what modifications, additions or deletions of the SEASAT-A satellite do you recommend to improve the usefulness of SEASAT type data to your operations?

References

Appendices